

### REMARKS

The Office Action dated August 7, 2006 has been received and carefully studied.

The Examiner objects to the Abstract because it exceeds 150 words (and is more than one paragraph). By the accompanying amendment, the Abstract has been amended to be less than 150 words and to be a single paragraph.

The Examiner objects to claim 4, stating that the ratio "0.5-5.0" should read "0.5-5.0:1". By the accompanying amendment, this change has been made.

The Examiner also objects to claim 7 since it does not end in a period. By the accompanying amendment, a period has been added to claim 7.

The Examiner objects to claim 8 because "g/.l." should read "g/l". By the accompanying amendment, this change has been made.

The Examiner rejects claims 1-11 under 35 U.S.C. §103(a) as being unpatentable over Ohmori et al., U.S. Patent No. 6,610,135, in view of the article "Preparation of Monodisperse ZrO<sub>2</sub> by the Microwave Heating of Zirconyl Chloride Solutions", by Young Tae Moon et al. and the article entitled "Preparation of Monodisperse and Spherical Zirconia Powders by Heating of Alcohol-Aqueous Solutions", also by Young Tae Moon et al. The Examiner states that Ohmori describes a method for making a titania sol by hydrolyzing titanium tetrachloride in an aqueous solution in the presence of a carboxylic acid so as to produce sol of titanium-

containing fine particles having an average diameter of 0.8 to 50 nm, in the concentration range and temperature range recited in the instant claims. The Examiner admits that Ohmori is directed to the production of a titania sol, not a zirconia sol, but considers this difference to have been obvious. The Moon et al. article is cited for its disclosure of using microwaves to uniformly heat a zirconyl chloride-containing solution. The second Moon et al. article was cited with respect to claim 4, for its disclosure of adding alcohol to the water solvent.

The rejection is respectfully traversed.

The present invention as claimed is directed to a method for the continuous preparation of a hydrous zirconia sol using a tubular reactor. High-quality, spherical, non-agglomerated and monodisperse in size nano-particles of hydrous zirconia particles are thus prepared in a tubular reactor in a continuous flow state. This is fundamentally different from Ohmori et al., which discloses a stirred reactor, and from both Moon et al. references, which disclose a non-stirred, static and non-flow state.

Furthermore, as the Examiner admits, Ohmori et al. relates to preparation of a titania sol, not a zirconia sol. The present invention as claimed recites spherical zirconia hydrate particles that are nearly uniform-sized spherical nano-particles that can be prepared only by a non-stirred, tubular reactor in a continuous flow state, not by a stirred reactor as taught by Ohmori et al. (Figure 1 and Examples 1-3). This is also supported by the

consistent emphasis of the first cited Moon et al. article at lines 9-20 of I. Introduction on page 1103, Figure 1 on page 1104, and (1) Stirring Effect on pages 1104-1105, and the second cited Moon et al. article at lines 21-27 of II. Experimental Procedure on page 2690, that stirring a solution should lead to shear-induced aggregation (agglomeration) and deterioration in shape and size distribution of product particles.

The differences in the reaction method and means between the present invention and the cited references, such as, the stirred vessel or tank of the references and the tubular reactor without stirring means and the irradiation of microwave to the stream so that the solution may be heated in a flow state; the non-uniform, irregular flow pattern within the reactor tank of Ohmori et al. compared to the uniform flow pattern with a constantly maintained velocity gradient in the radial direction of the present invention; and the change in temperature pattern with time compared to the solution temperature increases with tube distance of the present invention, leads to significant differences. Specifically, in the cited art, the stirred vessel results in a non-uniform, irregular flow pattern within the reactor tank, whereas in the present invention, a uniform flow pattern with a constantly maintained velocity gradient in the radial direction results (see Figure 2a, paragraph [0053], paragraph [0062] and paragraph [0071] of the published application. Also, the temperature pattern within the stirred vessel of the cited art

changes over time, and a uniform solution temperature within the reaction vessel is maintained due to stirring. In contrast, the solution temperature in the present invention increases with tube distance, see Figure 2 and paragraphs [0059] to [0065]. In addition, Ohmori et al. is a hydrolysis reaction with no mention of precipitation, whereas the instant reaction involves hydrolysis and precipitation (Figures 1 and 2 and paragraphs [0049] - [0060]). Hydrogen chloride vapor is a gaseous by-product in Ohmori et al; whereas there is no generation of HCl vapor in the instant method.

Since the reaction method as taught by Ohmori et al. yielded poor product quality in the case of hydrous zirconia particle synthesis, Moon et al. executed all experiments in a non-stirred flask with a small volume (60 cc) of starting solution (lines 8-9 of II. Experimental Procedure on page 1103 and (1) Stirring Effect on pages 1104-1105 of the first cited Moon et al. article; and lines 24-27 of II. Experimental Procedure on page 2690 of the second cited Moon et al. article).

According to the Moon et al. articles, synthesis of spherical zirconia powder is significantly influenced by such experimental conditions as stirring speed, temperature uniformity, and heating rate (lines 21-30 of I. Introduction on pages 1103 of the first cited Moon et al. article), and the product quality of spherical zirconia powders differs greatly depending on the synthesis method chosen even under the same chemistry (lines 1-34 of I.

Introduction on page 2690 of the second cited Moon et al. article). This means that, in view of the Moon et al. articles, one skilled in the art would not be motivated to apply the Ohmori et al. method applicable to the preparation of hydrous zirconia particles. Indeed, even for a specific material to be prepared (like zirconia particles), the most optimum method and means should be selected and optimized among various methods application to preparation of the specific material.

Furthermore, Ohmori et al. itself clearly emphasized that product should not be prepared in the form of dried powder because narrowly distributed spherical and non-coagulated particles cannot be obtained by drying of the aqueous sol obtained by the reaction (column 4, lines 19-26 and Examples 1-5). This is completely contrary to the object and observations in the present invention, and teaches away therefrom. Indeed, the shapes of the instant hydrous zirconia particles can be confirmed by SEM (as illustrated in Figure 6) in a dried state (paragraph [0109] on page 8 and Figure 6), and the hydrous zirconia particles are dried at 85°C for 24 hours and do not agglomerate (paragraph [0113] on page 8, [0116] through [0118] on page 9, [0122] and [0126] through [0127] on page 9). The discrepancy between Ohmori et al. and the present invention exemplifies the fundamental differences between Ohmori et al. and the present invention in terms of chemical backgrounds, reaction technology and means, and hydrodynamic and thermal environments pursued.

This discrepancy is also contrary to the Examiner's position that ". . . titanium and zirconium belong to the same chemical group in the Periodic Table, and elements within the same chemical group in the Periodic Table are known to have similar chemical and physical properties . . .". It is thus manifest that preparation of high-quality nanometer-sized hydrous zirconia particles should be prepared with a specifically selected method and conditions other than those taught by Ohmori et al. with respect to titanium.

With particular reference to the Moon et al. articles, key technical elements of the present invention as claimed are different from the teachings of Moon et al. Indeed, the instant specification at paragraphs [0014] to [0016] argues that the teachings of Moon et al. are valid only at a small volume flask (60 ml) in a non-stirred static state. The present inventors discovered that non-agglomerated (non-coagulated) high-quality product with spherical shape and narrow size distribution can be obtainable only by a precipitation method under a thermal environment provided in a flow state within a reaction tube even when microwave is selected as a heating medium.

For example, the first cited Moon et al. article teaches a batch-type process in a flask at lines 8-9 of II. Experimental Procedure on page 1103 ("the volume of the starting solution was 60 ml in all experiments."), at the second line of (1) Stirring Effect on page 1104 (" . . . immersion in a flask . . ."), and the reference to the Pyrex flask in the third and fourth line on page

1106.

Contrary to the teachings of Ohmori et al. and Moon et al., the present application claims a method of preparing hydrous zirconia particles in the state of a continuous tubular flow inside tube(s) and not in a stirred vessel (or tank)-type reactor (Ohmori et al.) or non-stirred vessel (or tank or flask)-type reactor (Moon et al.). A unique inventiveness of the present invention resides in that the best product quality of the hydrous zirconia particles can be obtainable only under the conditions of the velocity profile within a heated tube (as shown in Figure 1) and temperature increase along the tube distance following microwave irradiation (as shown in Figure 2), which cannot be obtainable with the tank- or vessel-type reactor used in the cited references.

Accordingly, the instant claims are not obvious over Ohmori et al. in view of the Moon et al. articles for the reasons articulated above.

The Examiner provisionally rejects claims 1-11 on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-16 of co-pending patent application Serial No. 10/510,264 in view of the article entitled "Preparation of Monodisperse  $ZrO_2$  by the Microwave Heating of Zirconyl Chloride Solutions" by Young Tae Moon et al. The Examiner states that the instant claims are obvious variations of the same method for continuously preparing a zirconia sol by heating a solution of

zirconium salt, the difference being that the claims of 10/510,265 require microwave heating of the solution. Moon et al. is cited for its disclosure that microwaves are an excellent means of uniformly heating a zirconyl chloride-containing solution to provide zirconia particles in a rapid fashion.

A terminal disclaimer is filed herewith.

Reconsideration and allowance are respectfully requested in view of the foregoing.

Respectfully submitted,



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